Pre-Conceptual Design of Demonstration Reactor Test Bed

May 13, 2020

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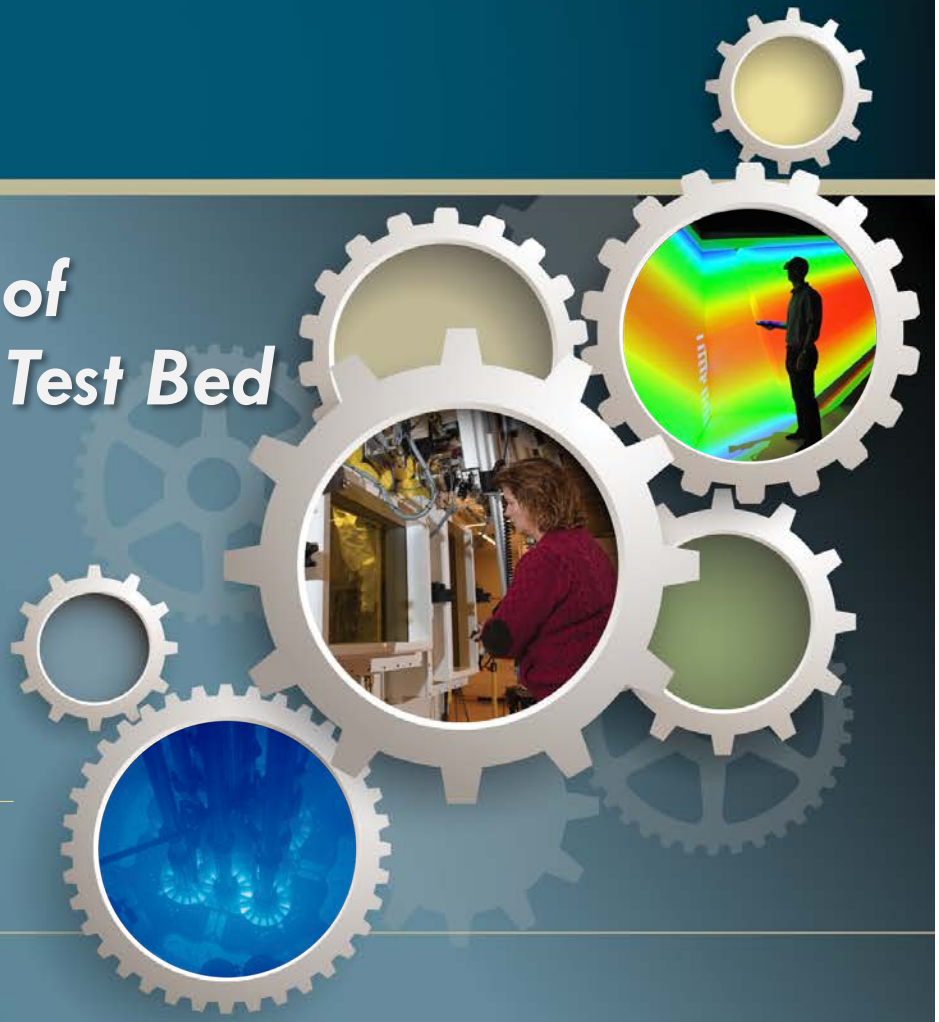
National Reactor Innovation Center



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NATIONAL REACTOR INNOVATION CENTER

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Demonstration Test Bed Requirements Gathering Initiative

NRIC needs your input to effectively enable your demonstration

In 2020, the National Reactor Innovation Center (NRIC) initiated projects to develop test beds to provide capable facilities to support reactor demonstrations. Two existing facilities at Idaho National Laboratory were chosen for initial test beds: the Experimental Breeder Reactor-II (EBR-II) dome and the Zero Power Physics Reactor (ZPPR). Each provides unique capabilities to enable a wide range of demonstration projects. To support preparing these facilities for demonstrations, NRIC is gathering requirements from potential users. Your responses, along with those of other potential users, will influence project decisions and become part of the formal requirement documentation.

Please note which requirements may be negotiable and feel free to contact NRIC with follow-up questions or clarifications.

Reactor demonstration projects are assumed to be modularly constructed, delivered, and installed into the test bed facilities. Other baseline technical assumptions for the facilities are as follows.

Parameter	 EBR-II	 ZPPR
Maximum Reactor Thermal Power (MW)	10	0.5
Maximum Floor Loading (lbs) (total/psf)*	Not evaluated / 3,750	500,000 / 3,000
Module Transfer Port and Location	Near ground-level Door/Hatch	Roof Hatch
Largest Dimension of Opening (ft)*	9	Up to 20
Usable Area Inside Containment (ft²)	~4,000	~1,300
On-site Power Available	200 kVA @ 480V	200 kVA @ 480V
Target Ready-for-Demonstration Date	End of 2023	End of 2023

*May be negotiable depending on needs

Demonstrator Requirement Input

1. **Heating and Cooling**
   Our thoughts thus far regarding heat rejection are that the demonstration site's HVAC system would be capable of rejecting a specific amount of thermal energy deposited from reactor operations. The site's HVAC system would then interface with the reactor's heat removal system, if any.
   1.1. Planned maximum thermal power (steady-state) of the reactor system (e.g. 500kW)?
   1.2. Please describe the planned cooling system for the reactor. Consider the following questions.
      1.2.1. If the reactor system includes a heat removal system, is it planned to be a closed loop?
      1.2.2. If gas is used for the primary cooling and is not a closed loop, what is the flow rate? This information supports understanding requirements for rejecting radionuclides to the environment outside of the demonstration facility.
   1.3. Describe any environmental (dew point, ambient temperature, humidity, etc.) requirements for inside the demonstration site?
2. **Mechanical/Structural**
   2.1. What are the general dimensions of the reactor system?
   2.2. What are the general dimensions of the largest component?
   2.3. What are the general dimensions of components needing transport via shielded cask?
   2.4. To aid in understanding floor loading limitations, what is the rough weight of the heaviest component? *Optionally, floor loading requirements can be provided.*
   2.5. To aid in understanding floor loading limitations, what is the rough weight of the combined system? *Optionally, floor loading requirements can be provided.*

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- Currently soliciting technical requirements information from potential demonstrators
- Feedback will inform design of:
  - Heat Rejection Systems
  - Mechanical/Structural
  - Lifting and Crane Support
  - Electrical
  - Gas Supply
  - Operations Support

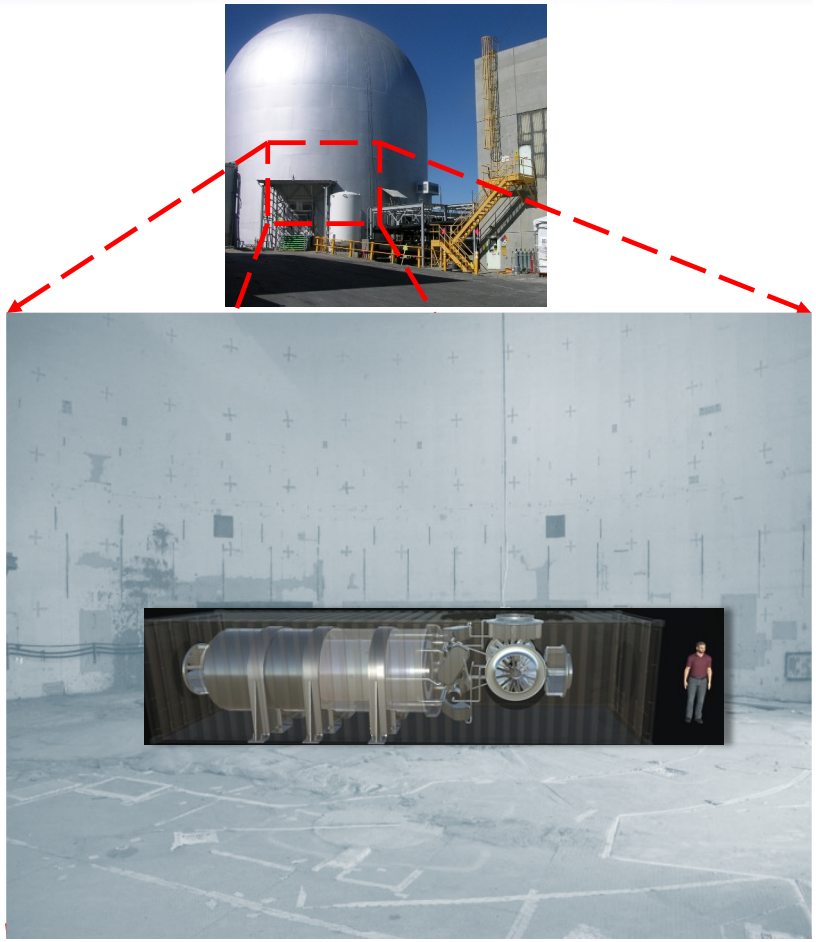
Pre-Conceptual Design of Test Beds
Phase 1 - Requirements Definition
Phase 2 - Technical Solution Definition
Phase 3 - Product Realization
Phase 4 - Technical Planning and Readiness

EBR-II Test Bed (ETB) Information

- 80 ft diameter, 1ft thick rebar reinforced concrete walls with steel plating on exterior
- Reactor can be co-located with existing capabilities at MFC
  - Fuel production, hot cells, characterization, and machine shop
- Floor loading capacity of 3,750 psf
- Available utilities, including electrical power, communications, and compressed gas systems
- ~4,800 sqft of floor space inside dome
- Near ground level entry point for installation of equipment
- Safeguards Category 2, Hazard Category 2

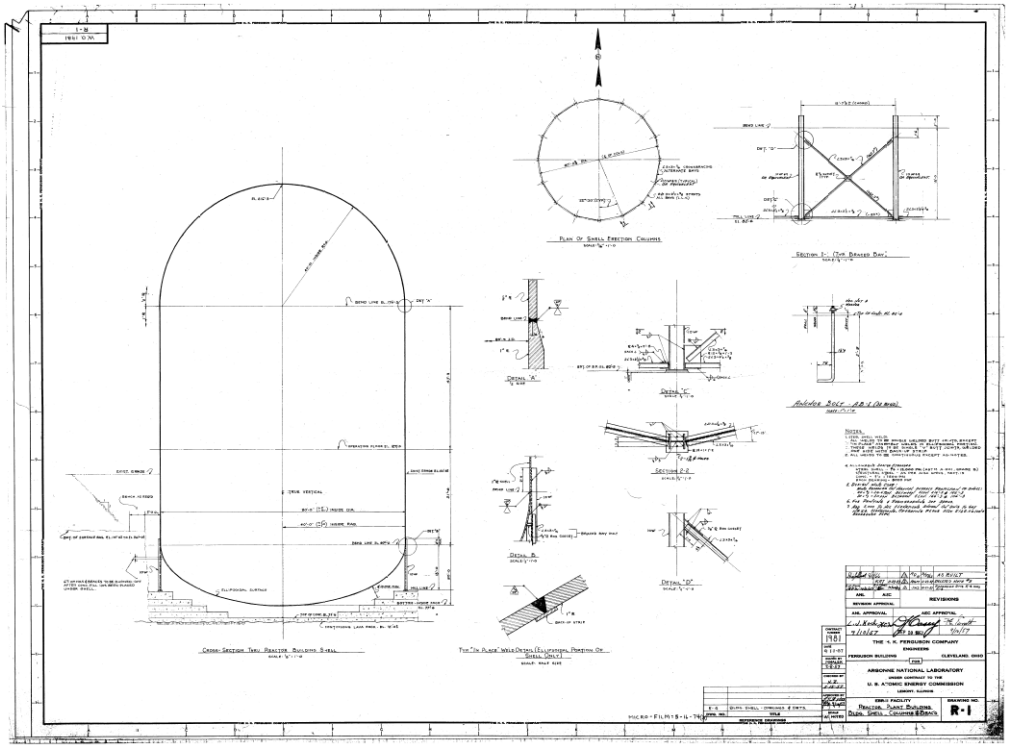
General Requirements: EBR-II Test Bed (ETB) for Demonstration Reactors

- ETB shall be capable of ***hosting operational nuclear reactors*** that meet Requirements & Limitations for use Criteria
  - Module size compatible with equipment door (est. 14' x 14')
  - Less than 20% enriched fuel
  - Less than 10MWt power production
- ETB shall provide dynamic capability to remove heat from containment
- ETB shall include a staging area for installation and removal of reactors
- ETB shall provide an integrated control room for operation of reactors and support systems
- ETB shall provide 200 kVA electrical service at 480V
- ETB shall be capable of handling externally clean used fuel containers from reactors
- ETB shall be capable of handling radioactive samples for Post Irradiation Examination (PIE) of reactor materials
- ETB shall include staff necessary for operations of reactors and maintenance of test bed systems
- ETB shall provide a system for physical and digital protection of demonstrator's intellectual property



Concept of Operations: EBR-II Test Bed (ETB) for Demonstration Reactors

- Reactors will be installed in the dome via a loading zone capable of handling trailer mounted containers (ex. Connex)
- Reactors will be removed utilizing the same path
- The ETB will consist of safety related structures and equipment to enable the critical operation of non-power reactors
- Intended to reduce time and money required to permit, install, commission, operate, and decommission demonstration reactors
- Safety basis broad enough to cover range of reactors
- INL to receive shipment of assembled demonstration unit and take ownership at MFC
- INL to install and commission the reactor in collaboration with innovator
- INL to train operators in collaboration with innovator
- INL to operate the reactor according to experimental plan developed with innovator
- INL to execute deactivation plan at end of life

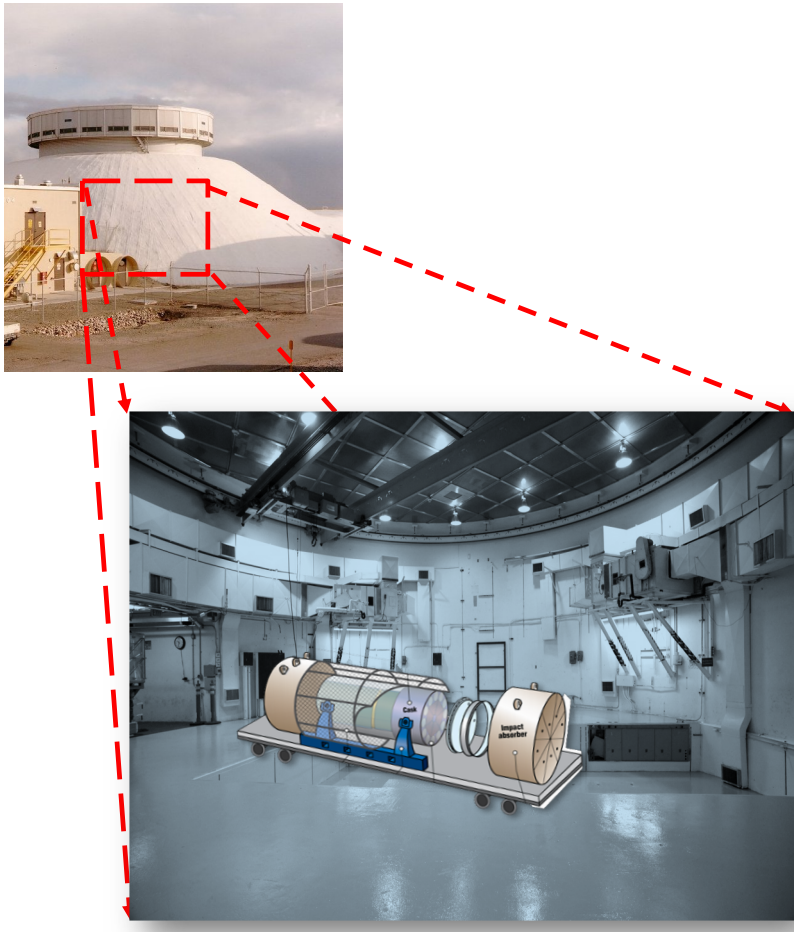


ZPPR Test Bed (ZTB) Information

- Built as Safeguards Category1, Hazard Category 2 facility for reactor operations
- HEU and Pu Fuel Capable
- Co-located with other MFC Capabilities:
  - Fuel production, hot cells, characterization, and machine shop
- Floor loading 3,000 psf or 500,000 lbs total
- 200 kVA, 480V electrical service
- Class 1E battery backup power and non-safety-related 100kW diesel generator
- Compressed gas systems
- ~1,300 sqft floor space
- Co-located Control Room
- Roof entry point for installation of equipment and reactor packages

General Requirements for ZPPR Test Bed (ZTB) for Demonstration Reactors

- ZTB shall be capable of ***hosting operational nuclear reactors*** that meet Requirements & Limitations for use Criteria
  - Module size compatible with equipment door (est. 20' diameter via roof hatch)
  - Greater than 20% enriched fuel
  - Less than 500kWt power production
- ZTB shall provide dynamic capability to remove heat from containment
- ZTB shall include a staging area for installation and removal of reactors
- ZTB shall provide an integrated control room for operation of reactors and support systems
- ZTB shall provide 200 kVA electrical service at 480V
- ZTB shall be capable of handling externally clean used fuel containers from reactors
- ZTB shall be capable of handling radioactive samples for Post Irradiation Examination (PIE) of reactor materials
- ZTB shall include staff necessary for operations of reactors and maintenance of test bed systems
- ZTB shall provide a system for physical and digital protection of demonstrator's intellectual property



Concept of Operations: ZPPR Test Bed (ZTB) for Demonstration Reactors

- Reactors will be installed in the cell via a roof mounted entry point
- Reactors will be removed utilizing the same path
- The ZTB will consist of safety related structures and equipment to enable the critical operation of non-power reactors
- Intended to reduce time and money required to permit, install, commission, operate, and decommission demonstration reactors
- Safety basis broad enough to cover range of reactors
- INL to receive shipment of assembled demonstration unit and take ownership at MFC
- INL to install and commission the reactor in collaboration with innovator
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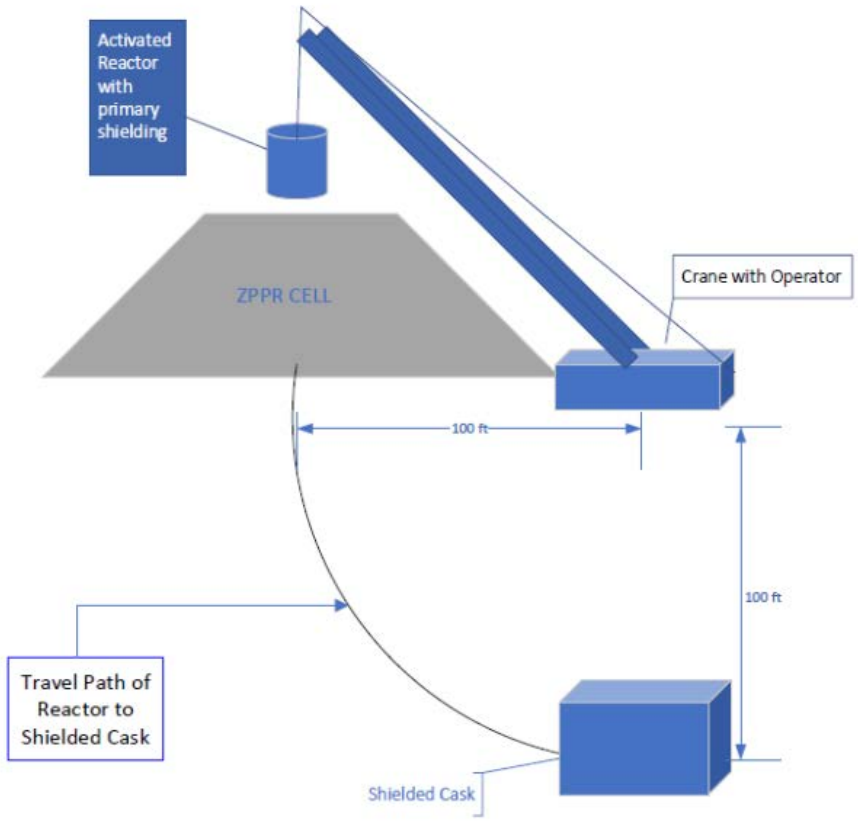
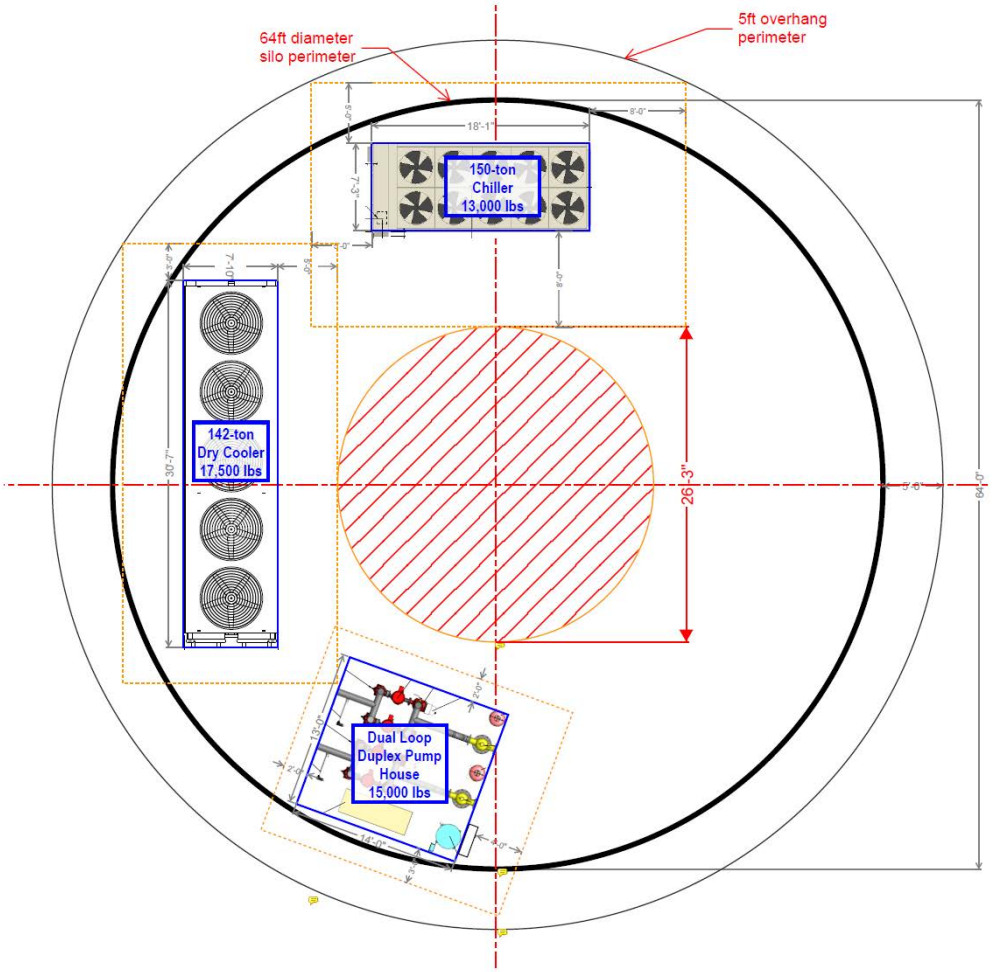
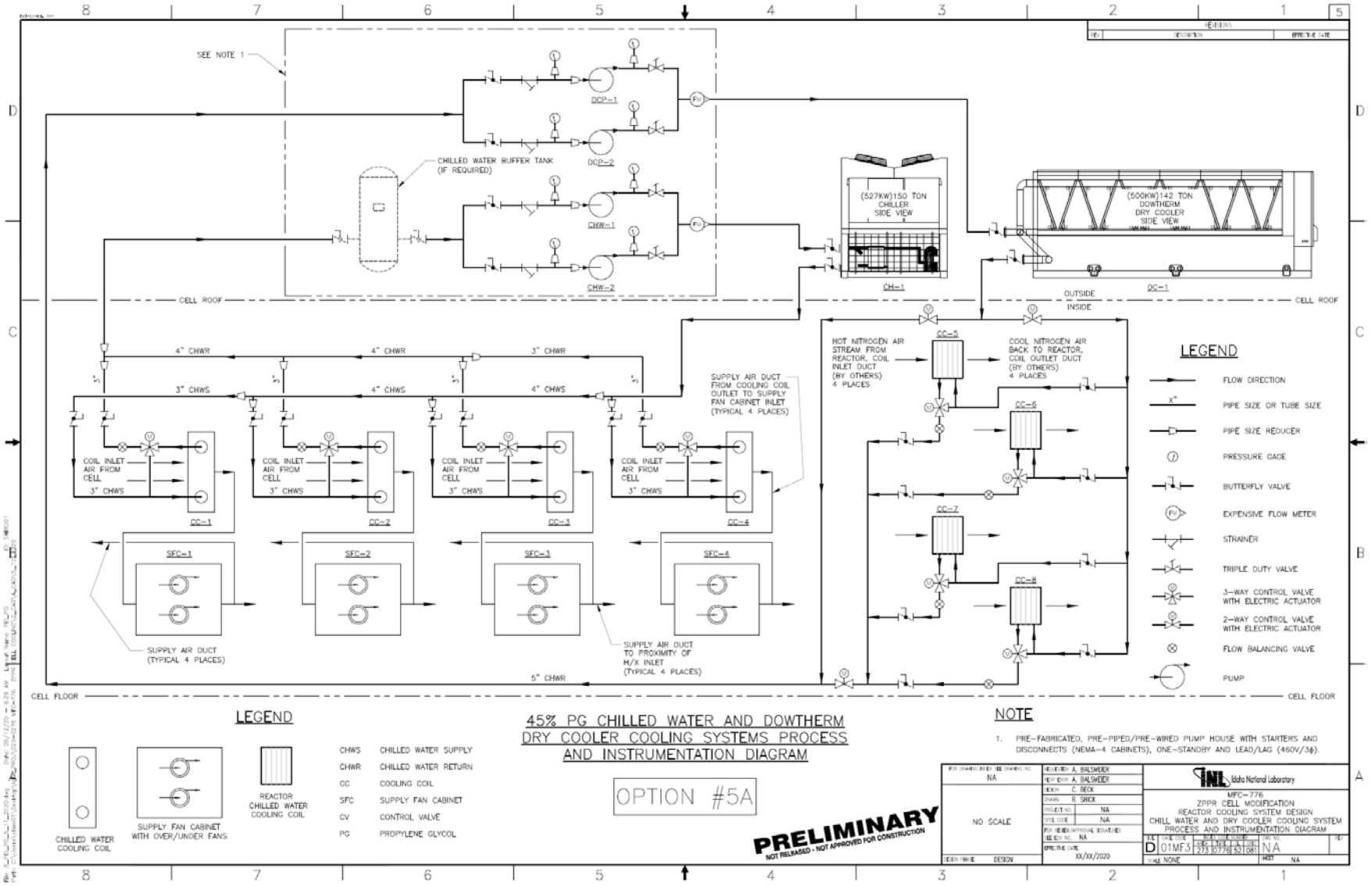


ZPPR (FAC)

- Building and Equipment (100)
- Power Systems/Equipment (200)
- Radiation and Contamination Monitors (300)
- Air/Ventilation Systems Equipment (400)
- Glove Box Systems, Hoods, and Equipment (600)
- Misc. Systems/Equipment (700)
- Material Handling Equipment/Storage (800)

INL ZPPR Reactor
Option #5A Roof Equipment Layout
Using DOWTHERM Q fluid in ONE Dry Cooler





LEGEND

CHILLED WATER COOLING COIL

SUPPLY FAN CABINET WITH OVER/UNDER FANS

REACTOR CHILLED WATER COOLING COIL

CHWS	CHILLED WATER SUPPLY
CHWR	CHILLED WATER RETURN
CC	COOLING COIL
SFC	SUPPLY FAN CABINET
CV	CONTROL VALVE
PG	PROPYLENE GLYCOL

45% PG CHILLED WATER AND DOWTHERM DRY COOLER COOLING SYSTEMS PROCESS AND INSTRUMENTATION DIAGRAM

OPTION #5A

PRELIMINARY
NOT RELEASED - NOT APPROVED FOR CONSTRUCTION

NOTE

1. PRE-FABRICATED, PRE-PIPED/PRE-WIRED PUMP HOUSE WITH STARTERS AND DISCONNECTS (NEMA-4 CABINETS), ONE-STANDBY AND LEAD/LAG (460V/3ϕ).

REQUIRED BY	A. BALSMEIER
REV. DSGN.	A. BALSMEIER
DESIGN	C. BECK
DRAWN	R. SHOX
PROJECT NO.	NA
COST CODE	NA
FOR REVIEW/APPROVAL SIGNATURES	
SEE ECN NO.	NA
EFFECTIVE DATE	XX/XX/2020
NA	
NO SCALE	
DESIGN PHASE	DESIGN

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MFC-776
ZPPR CELL MODIFICATION
REACTOR COOLING SYSTEM DESIGN
CHILL WATER AND DRY COOLER COOLING SYSTEM PROCESS AND INSTRUMENTATION DIAGRAM

SIZE	DRAWING NO.	REV
D	01MF3 273107761521081	NA
SCALE NONE		HOT NA

Progress on Test Bed Pre-Conceptual Design to date:

- Initiated Technical Requirements Gathering from Stakeholders

- ETB General Requirements Document
- ETB Initial ConOps Document

- ZTB General Requirements Document
- ZTB Initial ConOps Document
- ZTB Functional & Operational Requirements Document
- ZTB System Breakdown Structure
- ZTB Heat Rejection Architecture Design of Alternatives

Additional projects to enable rapid demonstration of reactor concepts proposed by industry

- **Risk reduction in DOE authorization process for demonstration reactors**
  - Utilize generic, enveloped, demonstration reactor parameters to initiate DOE facility authorization process
- **Risk reduction in NEPA process for demonstration reactors**
  - Utilize generic, enveloped, demonstration reactor parameters to initiate NEPA process
- **Preparation of new fuel production infrastructure**
- **Provision of satellite office space for on-site collaboration with industry partners**
  - Meeting space enabling industry to work and host events for potential customers, investors, and others


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